APPLICATION

FOR

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TITLE: SYSTEM AND METHOD OF USE OF EXPANSION ENGINE TO INCREASE OVERALL FUEL EFFICIENCY

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System and Method of Use of Expansion Engine To Increase Overall Fuel Efficiency

CLAIM OF PRIORITY

The present application claims priority on U.S. Provisional Application Serial No. 60/432,056, filed December 9, 2002.

TECHNICAL FIELD

The present invention relates to a system and method of use of a gas expansion engine to recover potential energy when the gas pressure is lowered and thereby increase the fuel efficiency of an industrial system containing the gas expansion engine.

BACKGROUND

Any pressurized gas contains potential energy. When the gas's pressure is lowered, by use of a gas expansion engine, it is possible to recover some of this potential energy both mechanically and/or electrically, especially when the expansion engine is coupled to an electric generator. Therefore, in any system with suitable gas volume flows and pressure regulation differentials, energy can be recovered. This can then be applied to many differing applications to increase fuel efficiency. Examples include natural gas regulation stations, process gas regulation, power plants and energy recovery from heat sources, to name but a few.

Furthermore, when the gas is expanded the gas's temperature will drop considerably. Depending upon the application, this dramatic temperature drop can be taken advantage of; for example, the "coldness" created by the pressure drop can be used for air conditioning, to make ice or to cool other elements and/or processes, to name but a few.

SUMMARY

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

The present invention is a system of increasing overall fuel efficiency at a facility. The system includes a gas expansion engine for receiving a supply of pressurized gas of a first pressure and first temperature and outputting tail gas of a second lower temperature and a lower pressure. Additionally, the gas expansion engine outputs rotational energy via a rotating shaft. An electric generator and/or rotating machinery is driven by the rotating shaft of the gas expansion engine.

A heat exchanger may be used to transfer heat to the tail gas of the expansion engine from an HVAC apparatus, an ice making apparatus or other plant process equipment thus providing a mechanism for chilling.

At least a portion of the tail gas of the gas expansion engine may be used for fuel gas in other industrial processes or directed into a municipality gas distribution network.

A method of increasing overall fuel efficiency for a facility includes the steps of providing a supply of pressurized gas having a first pressure and first temperature to a gas expansion engine; extracting rotational energy from the gas expansion engine; using the tail gas from the outlet of the expansion engine as a source of cooling for an HVAC apparatus or an ice making apparatus or other plant process equipment.

The method may further include use of the tail gas as fuel gas in other industrial processes or directed into a distribution network for gas distribution.

DESCRIPTION OF DRAWINGS

The disclosed invention will be described with reference to the accompanying drawings, which show important sample embodiments of the invention and which are incorporated in the specification hereof by reference. A more complete understanding of the present invention may be had by reference to the following Detailed Description when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partial cross-section of a prior art piston type gas expansion engine;

FIG. 2A is a partial schematic of a prior art piston type gas expansion engine;

FIG. 2B is a partial schematic of a prior art turbo expander type gas expansion engine;

FIG. 3 is a schematic of a first embodiment of the system of the present invention;

FIG. 4 is a schematic of a second embodiment of the present invention;

FIG. 5 is a schematic of a third embodiment of the present invention;

FIG. 6 is a schematic of the system of the present invention that includes multiple heat exchanges ("HE") used to increase fuel efficiency for the system; and

FIG. 7 is a perspective view of a skid mounted gas expansion engine coupled to an electric generator.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Reference is now made to the Drawings wherein like reference characters denote like or similar parts throughout the Figures.

In the present invention the basic energy source is the release of potential energy from pressurized gas through gas expansion. As used herein a gas expansion engine is any device for converting potential energy stored in high-pressure gas to mechanical energy. In a gas expansion engine, the gas engine functions as a compressor in reverse. There is no combustion in a gas expansion engine. There are two main kinds of gas expansion engines: a piston type engine and a turbo (turbine) expander type engine.

Referring now to Figure 1 wherein is disclosed a partial cross-section view of a prior art gas expansion engine 100 of the piston type. Pressurized inlet gas enters the engine 100 at inlet 110 through control valve 120 and is directed to the front or backside of double acting piston 130. Piston 130 is movable connected via connecting rod 140 to crank shaft 150. As piston 140 moves back and forth in the cylinder 132, so does the connecting rod 140 thereby acting upon the crank shaft 150 and producing rotation. Lower pressure gas, having converted to mechanical energy some of its potential energy from being at a higher-pressure inlet gas, is expelled through gas outlet 160. Reciprocating piston gas engines are well known in the art and may contain single or double acting pistons as well as single or multiple cylinders. Figure 2A is a schematic that illustrates how a piston type gas expansion engine converts pressure drop from the inlet gas, in the piston cylinder, into power by driving a piston attached to a rotatable shaft. Figure 2B is a schematic that illustrates how a conventional turbo expander ("turbine engine") 200 converts pressure drop in the inlet gas 202 flowing through the turbine vanes 260 into mechanical energy through a rotatable shaft 270 attached to the turbine blades. Turbo expander engines are well known in the art.

Applications of the present invention may be initially divided into two groups: open systems and closed systems. Figure 3 illustrates an example of an open system. Such a system might be located at a natural gas regulation station, where natural gas comes in from a

high pressure pipeline 300 and exists to a lower pressure distribution network 310. Mechanical energy is recovered from the potential energy of the inlet by the gas expansion engine and can be used to drive a mechanical device and/or an electrical generator; the cooling effect of the pressure drop may be used for air conditioning, process cooling or some other form of chilling or cooling..

Figure 4 is a schematic that illustrates an example of a closed system that may include a cooling system where a refrigerant 400 is contained and circulated around within a closed loop system. For example, the cooling effect 410 of the pressure drop can be used in air conditioning and process cooling in a plant environment, similar to a typical HVAC system. In a typical HVAC system an expansion valve would be used in place of the expansion engine. An expansion valve is incapable of capturing and transforming the potential energy (from the pressure drop and flow) into mechanical rotation. Thus when an expansion engine is used to replace the expansion valve, energy maybe recovered in the form and through a rotating shaft. This rotating shaft is then connected either directly or by some method to the compressor, thereby directly allowing the recovered energy from the expansion engine to drive the compressor. Due to overall system losses the energy from recovered by the expansion engine is less than that required to operate the compressor on a continuous basis. Therefore the additional energy may come from another device such as an electric motor. Using this scenario, the expansion engine can be considered to be aiding the electric motor as it drives the compressor, thus decreasing the amount of (electrical) energy required to drive the motor, thus saving energy and running costs. Also, it should be noted, that a smaller electric motor maybe required as its size is often determined by the electrical power requirements. This is an example of recapturing energy and making a system more energy efficient.

The gas exiting the expansion engine is at a lower temperature and pressure. As this same gas passes through the heat exchanger, the temperature of the gas will rise. This warmer temperature gas then enters the compressor. The compressor works upon the gas and thus the gas exiting the compressor will be both at a higher temperature and pressure. This gas then passes through another heat exchanger that lowers the temperature of the higher pressurized gas, which then passes to the inlet of the expansion engine. Thus the cycle continues again, as per the start of this paragraph. In figure 4, the expansion engine recovers

less energy than is required by the compressor and thus only reduces the amount of energy required by an electric motor/generator to drive the compressor.

Figure 5 illustrates another embodiment of a closed system of the present invention. Figure 5 discloses use of an external heat source 500 such as heat from boiler fire gas, waste heat from engines, and waste heat from condensers to increase the fuel efficiency of the system. Whereas in the embodiment of Figure 4 the primary purpose was to produce cooling for chilling and/or AC, whereby the expansion engine recovers energy and allows for a reduction in energy consumed by such a process, the embodiment of Figure 5's primary purpose is convert waste heat into energy. The energy may be utilized for any number of purposes including electrical power generation or mechanical drive. Similar to Figure 4, the expansion engine in Figure 5 derives its energy from gas expansion. But in Figure 5, the expansion engine recovers more energy than is required by the pump and thus is a net generator of power, typically electrical power generation through the use of the electric motor/generator acting as a generator. The energy for the net power generation is derived from transforming the waste heat that is inputted into this closed system from the external heat source via the heat exchanger.

Figure 6 is a schematic of the system of the present invention that includes higher pressure inlet gas 102 passing through expansion engine 100 or 200 and exiting the system as lower pressure gas 104. Since the expansion engine has moving parts and typically those parts need to be lubricated, and since the temperature of the lubrication will tend to rise, Figure 6 shows additional methods for reclaiming energy and increasing overall energy efficiencies by transferring the otherwise waste heat from the generator and expansion engine lubrication to the gas stream to be proportionally transformed back into useful mechanical energy through the expansion engine's rotating shaft and potentially into electricity via a generator. This is clearly shown through the use of multiple heat exchangers HE2 and HE3 which add waste heat to the inlet gas 102 to increase fuel efficiency. Heat exchanger HE4 takes cooling generated by the gas expansion and potentially uses the cooling for air-conditioning or ice making.

The present invention includes many benefits including reducing the total price of power generation and reducing total power consumption requirements. Analysis indicates that the average cost of power generation is typically half the cost of power produced by use of combined heat and power (CHP) units.

When the present invention is utilized in connection with an industrial facility that is not primarily an electric power generating plant, the system provides a separate uninterruptible source of electric power for the industrial facility. A separate uninterruptible non-utility based electric power source is desirable in many industrial settings. Use of the present invention may result in surplus electric power that may be sold to lower the total cost of energy to an industrial facility.

Since the invention allows for net power generation and connection to a power grid, it also allows for potential improvements of a facility's electrical power factor and thus potentially reducing financial penalties associated with power factor that the facility may incur from its electrical power supplier.

In some embodiments of the present invention, energy efficient cooling is provided by the colder outlet gas as the temperature drops as the inlet gas is expanded to the lower pressure.. This cooling can be used in industrial process applications using heat exchangers for process cooling and for ice manufacturing, to name but two. Additionally, the cooling may be used as a source for air conditioning.

The present invention may be located at any location with a high-pressure source of gas. Some of these locations may be a city's fuel gas regulation station, i.e. a city gate or district station, for a natural gas distribution system. The present invention may be located in large manufacturing plants, process plants and power generation plants. Examples of some industrial plant uses include plants producing fertilizer; automotive vehicles and parts; chemical plants; paper mills; dry wall and press board plants; heat treatment facilities; steel mills and aluminum smelters. Example locations where potential air-conditioning benefits of the present invention may be used include shopping malls, airports, skyscrapers and sports stadiums.

As will be understood by those skilled in the art, the benefits, locations and uses disclosed herein are merely exemplary and not an exhaustive list of all possible uses and locations for the present invention.

Referring now to Figure 7, the present system may be prepackaged as a preassembled composite system 1000. The preassembled system 1000 may be mounted on a skid 1002 and comprise a gas expansion engine 1010 and an electric generator 1020. It will be understood by those skilled in the art that any type of rotating machinery needing a rotary power source may be used in place of the generator 1020. Such prepackaging reduces overall

manufacturing and installation costs and reduces construction and installation time. Prepackaged systems may be manufactured for standard uses or may be customized for the individual site and user criteria.

One or more preferred embodiments of the invention have been illustrated in the accompanying Drawings and described in the foregoing Detailed Description. It will be understood that the invention is capable of numerous modifications without departing from the scope of the invention as claimed.